Partial quenching and chiral symmetry breaking

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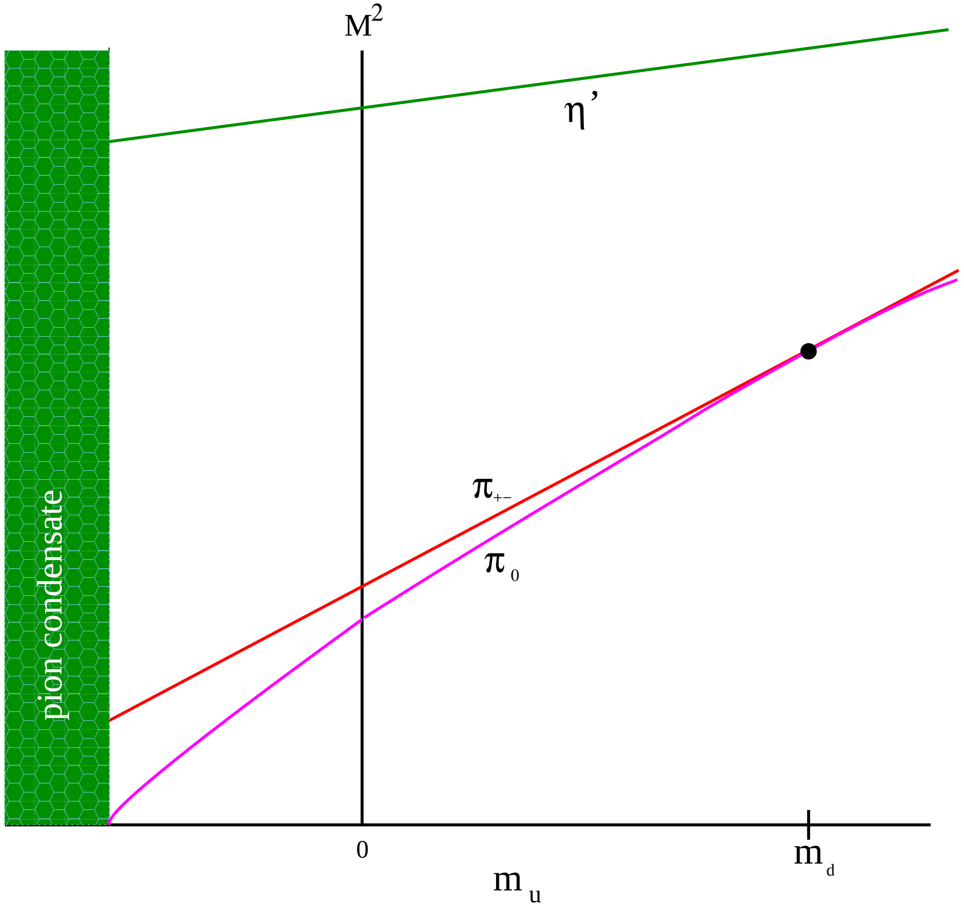

Pseudoscalar spectrum versus m_u at fixed $m_d \neq 0$

Partial quenching

- generate dynamical lattices with fixed “sea” quark masses
- study quark propagators with different “valence” quark masses.
- from these form “valence” bound states

Usual assumption

- as valence masses go to zero
  - a valence condensate $\langle\overline{\psi}_{val}\psi_{val}\rangle \neq 0$ forms
  - valence pion masses go to zero

In some cases this assumption can fail

Consider two non-degenerate flavors "u" and "d"

- chiral symmetry for the dynamical pions
  - $M_\pi \sim \frac{m_u+m_d}{2} + O(m_q^2)$

Fix $m_d \neq 0$ but take $m_u = 0$

- $M_\pi \sim m_d/2 \neq 0$
- no singularity for m_u in the vicinity of zero
  - "Dashen phase" at $m_u = -m_d + O(m_d^2)$

Banks and Casher

- small imaginary eigenvalues of the Dirac operator $\rho(0)$
- generate a jump in the condensate $\langle\overline{\psi}\psi\rangle$ as m_q passes through zero

No jump in sea $\langle\overline{u}u\rangle$ at $m_u = 0$ when m_d remains finite

At vanishing m_u the up quark propagator has $\rho_u(0) = 0$

Bring in the valence quarks and take m_{val} to zero

- the valence propagator and the up quark propagator become the same
  - $D_{val} \to D_u$ as $m_{val} \to 0$
  - $\rho_{val}(0) \to \rho_u(0) = 0$

Valence quarks do not condense

- no valence chiral symmetry breaking
- no expectation for massless valence pions

Conclusion

- partially quenched perturbation theory can fail if $\langle m_{val} \rangle < \langle m_s \rangle$
  - independent of lattice fermion formulation
  - a consequence of the anomaly